Retrospective Study

Minimally Invasive Sacroiliac Joint Fusion: Posterior Graft Implant vs. Lateral Arthrodesis with Compression Screw Hardware at a Pain Management Center

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Background: The sacroiliac joint (SIJ) is a frequently overlooked source of lower back pain (LBP), contributing to 15-30% of cases. Nonoperative treatments such as NSAIDs, physical therapy, and SIJ injections have limited effectiveness on LBP. When conservative measures fail, SIJ fusion is recommended, with minimally invasive techniques showing better outcomes than traditional open surgery. However, there is no clear agreement on the optimal approach for SIJ fusion.

Objectives: This study aims to evaluate the outcomes of minimally invasive SIJ fusion performed by a single surgeon, comparing the lateral and posterior approaches to another in terms of pain relief, functional improvement, and procedure durability.

Study Design: A retrospective comparative study.

Setting: A single pain management center at the Interventional Pain Institute, where patients underwent SIJ fusion between April 2020 and May 2024.

Methods: A total of 115 patients who underwent minimally invasive SIJ fusion and met the inclusion criteria were included in the study. Patients were assessed before and after the procedure for pain using the Visual Analog Scale (VAS), functional outcomes using the Oswestry Disability Index (ODI), opioid consumption, sleep quality, and procedure durability. Statistical comparisons between the lateral and posterior approaches were performed using the chi-square (χ^2), Fisher's exact test, and t-test as appropriate, while durability was analyzed with the Kaplan-Meier curve and log-rank test.

Results: The average follow-up duration was 11.3 ± 5.8 months. Lateral SIJ fusion demonstrated longer procedural durability compared to the posterior approach, with greater improvements in VAS pain scores (66.3% vs. 53.8%, $P = 0.017$), ODI functional outcomes (45.0% vs. 30.7%, $P = 0.002$), higher rates of sleep improvement (83.9% vs. 61.0%, $P = 0.006$), and lower recurrence rates (12.5% vs. 28.8%, $P = 0.031$). At the last follow-up, most patients (79.1%) maintained their improvements.

Limitations: This study is limited by its retrospective design, its single-center setting, and the lack of randomization between the lateral and posterior approaches.

Conclusion: Both the lateral and posterior approaches to minimally invasive SIJ fusion were beneficial. However, the lateral approach used in our study demonstrated superior outcomes in the areas of pain relief, functional improvement, and procedure durability. Further multicenter prospective studies with larger patient populations are recommended to confirm these findings.

Key words: Lower back pain, sacroiliac joint fusion, sacroiliitis, minimally invasive surgery, lateral technique, posterior technique

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Lower back pain (LBP) is the most common type of pain reported by adults and is the leading global cause of disability. In 2020, LBP affected 619 million people worldwide, and cases were projected to reach 843 million by 2050 (1). LBP is a severe and debilitating condition carrying a disability burden comparable to that of epilepsy, tuberculosis, moderate dementia, severe motor impairment, moderate stroke, gastric bleeding, and severe COPD (2). For clinicians, patients with chronic LBP present a diagnostic challenge. Over 85% of LBP cases are classified as nonspecific, since they cannot be linked to a specific disease or spinal abnormality (3). In 2006, the total costs associated with LBP in the United States exceeded $100 billion per year (4). Overall, when LBP prevention and management are suboptimal, the clinical and economic burdens are substantial (5).

The sacroiliac joint (SIJ) is a large, diarthrodial, load-bearing synovial joint, supported by the sacroiliac ligaments and pelvic muscles (Fig. 1). Current research into the pathophysiology and risk factors of SIJ dysfunction indicates that it can result from various clinical conditions, as well as abnormal motion, including hypermobility, hypomobility, or malalignment of the joint (6). SIJ pain is one of the most overlooked causes of LBP and has been identified as the source of pain in 15% to 30% of patients presenting with LBP, an exceptionally high figure considering the total number of patients who present with LBP each year (7,8). Furthermore, the SIJ can be the source of LBP in most patients with prior lumbar fusion (9,10). The condition has been shown to cause decrements in quality of life that are at least as severe as or more than those associated with other well-known spinal conditions, such as spinal stenosis and intervertebral disc herniation (11). SIJ pain can arise from a variety of clinical conditions, making the diagnosis challenging. Equally challenging is managing this condition with nonoperative treatments, such as NSAIDs, physical therapy, and SIJ injections, which have limited effectiveness and lack robust evidence in support of their use for SIJ pain (12,13).

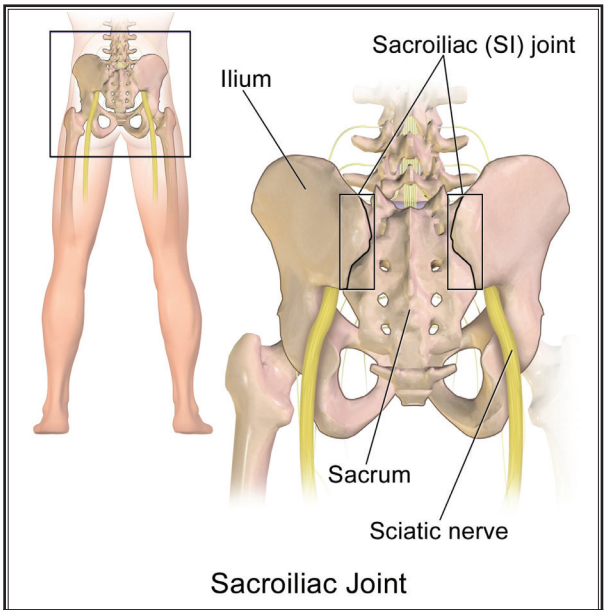

Fig. 1. *Anatomical illustration of the sacroiliac joint.* Source: Blausen.com staff. Medical gallery of Blausen Medical 2014. WikiJournal of Medicine (2). https://en.wikiversity.org/wiki/WikiJournal_of_Medicine/Medical_gallery_of_Blausen_Medical_2014#/media/File:Sacroiliac_Joint.png. Published 2014.

Chronic SIJ pain management continues to be a topic of debate. SIJ fusion has emerged as the standard treatment for patients with persistent SIJ pain that fails to respond to conservative measures (14,15). Traditional open SI joint fusion surgery, reported in the literature, is a complex and invasive procedure involving open exposure of the joint, followed by decortication and instrumented fixation using screws, cages, and bone grafts. This approach carries a high risk of significant complications, including blood loss, neurovascular injury, long hospital stays, and prolonged non-weight-bearing recovery (16,17). In recent years, minimally invasive (MI) SIJ fusion has gained popularity as a preferred alternative, aiming to reduce the surgical morbidity associated with open procedures (18,19). Studies on MI SIJ fusion have shown it to significantly reduce postoperative pain and improve perioperative outcomes compared to traditional open surgeries. These improvements are due to reduced soft-tissue damage, lower blood loss, shorter operative times, fewer complications, and quicker recovery (20-22).

The number of MI procedures for SIJ pathology has grown substantially, with 76.5% of SIJ fusions being performed minimally invasively between 2015 and 2020 in the Medicare population (23). Several techniques for SIJ fusion have been developed, including lateral, posterior, and posterior oblique approaches, with numerous implantable devices approved for SIJ fixation (24). However, the clinical data comparing the effectiveness of these systems is limited. The lateral transiliac approach, also known as arthrodesis with a transfixation device, is currently the most evidence-supported technique (25). While a small number of studies describe the use of hollow modular anchor screws, a larger number

describe the use of triangular titanium implants (TTIs) with a porous surface, which have been associated with significant reductions in pain and disability scores over spans of 12 to 24 months (26). Procedures that do not use transfixation are typically performed using a dorsal (posterior) approach. The posterior-fusion approach has shown promising results, including shorter operative times and less blood loss (27). However, the evidence for these non-transfixation techniques is less robust due to fewer studies and shorter follow-up periods (26).

Overall, SIJ fusion appears to provide sustained long-term benefits in terms of pain relief and quality of life for patients unresponsive to conservative treatments. However, there is limited published data on long-term clinical and fusion outcomes, and there is no consensus on the optimal approach or technology for MI SIJ fusion (28). To address this knowledge gap, we conducted a retrospective comparative study of posterior graft implants and lateral arthrodesis with compression screw hardware for SIJ fusion at a pain management center in St. Louis, Missouri. This study aims to evaluate the outcomes of minimally invasive SIJ fusion, comparing the 2 techniques in the areas of pain relief, functional improvement, and procedure durability. This study was a retrospective observational comparative analysis conducted between August 12 and October 11, 2024, using a convenience sampling strategy to select patients. The study was conducted at a single pain management center specializing in interventional treatments for chronic pain.

Methods

Patient data were retrieved through a chart review using the eClinicalWorks (EMR) software, with individuals identified based on specific current procedural terminology (CPT) codes for SIJ fusion procedures. The study included adult patients aged 18 to 99 who had undergone SIJ fusion via either the lateral or posterior approach between April 1, 2020, and May 1, 2024, with all procedures performed by a single surgeon at the center to ensure consistency. Inclusion criteria were designed to select patients with definitive SIJ dysfunction, requiring moderate to severe pain with functional impairment, persistent pain despite at least 6 months of intensive nonoperative treatment, at least 80% pain reduction after image-guided, contrast-enhanced SIJ injections on 2 separate occasions, a positive response to 3 out of 5 provocative tests (thigh thrust, compression, Gaenslen's test, distraction test, and FABER test), and confirmation through diagnostic imaging. Exclusion criteria aimed to mitigate potential selection bias by excluding cases in which variables could confound the results. These cases included procedures not performed by the study surgeon, removal of SIJ compression screw hardware due to intolerance, patients who did not complete the minimum 3-month follow-up, those with traumatic injuries before or after surgery, uncontrolled psychiatric conditions, or potential secondary gain situations such as workers' compensation cases. These criteria ensured a clinically relevant and homogenous cohort, minimizing bias while enhancing the reliability and validity of the study outcomes. Patients were divided into 2 groups, based on the SIJ fusion technique used on them: the posterior graft implant (referred to as the posterior approach) and lateral arthrodesis with compression screw hardware (referred to as the lateral approach). Patients were assessed pre-procedurally and on the last known follow-up (on or before August 9, 2024), using the Visual Analog Scale (VAS) for pain (0 = no pain, 10 = worst pain), the Oswestry Disability Index (ODI) for functional outcomes (0% = no disability, 100% = maximum disability), opioid consumption, improvement in sleep quality, and procedure durability. In cases of patients who underwent procedures on both sides, data from the first side operated on were used, since this allowed for a longer follow-up period. Improvements in VAS and ODI scores were calculated using the equation: Percentage improvment=((Reduction in score)/(Original score))×100. Quality of sleep was assessed using question 7 of the ODI questionnaire (29), with improvement defined as a change from admitting sleep disturbances before the procedure to denying sleep disturbances at the last follow-up. Procedure durability was defined as the duration of pain relief and functional improvement without the requir additional interventions or surgeries, while recurrence was identified as a decline in improvement or the need for additional interventions, opioid use, or surgery by the time of the last follow-up.

Ethical Considerations

An institutional review board (IRB) waiver was granted by BeyondBound IRB (IRB ID#: BB2408MN-015) on August 3, 2024. All patient data collected were de-identified to ensure confidentiality and compliance with the Declaration of Helsinki. Because the study involved a retrospective review of de-identified data, a waiver of informed consent was requested and granted, in accordance with exemption criteria.

Statistical Analysis

Categorical variables were reported as frequencies and percentages, and continuous variables as means with standard deviations. Comparisons between lateral and posterior approaches were made using the chi-square (χ^2) test, Fisher's exact test, or t-test as appropriate. Procedure durability was analyzed using the Kaplan-Meier curve and compared using the log-rank test. All statistical analyses were performed using IBM SPSS Statistics 29.0 (IBM Corporation). *P*-values < 0.05 were considered statistically significant.

Surgical Technique

In this study, 2 minimally invasive approaches—posterior and lateral—were used for SIJ fusion to treat patients with SIJ dysfunction. Both procedures aimed to stabilize the joint and reduce pain while minimizing tissue disruption.

Posterior Approach

For the posterior approach using the graft implant, patients were placed in a prone position, either under general anesthesia or local anesthesia with sedation. Fig. 2 shows graphical illustrations of SIJ fusion using the posterior approach technique employed in this study. Fluoroscopic guidance was used throughout the procedure to ensure the accurate placement of instruments. First, pins were inserted into the sacroiliac joint at angles of 70-90° to one another in the anterior-posterior plane, as seen in the lateral view (Fig. 2A). The placement of these pins was confirmed using lateral imaging. The finder was then placed over the Steinmann pin, and advanced until the stop bottomed out on the sacrum (Fig. 2B). Next, the guide retraction tube was placed over the finder and impacted gently into the joint space until the stop contacted the sacrum (Fig. 2C). Both the finder and Steinmann pin were then removed, and the drill was advanced until the safety stop contacted the top of the retraction guide tube (Fig. 2D). A square broach with a round pilot was inserted into the retraction guide tube to prepare the graft site (Figs. 2E, 2F). The 9 mm^3 CornerLoc® DBM sponge (Spinal Institute of North America), composed of cancellous bone, was compressed and inserted into the graft hole using the final impactor (Fig. 2G). The DBM sponge expanded back into the graft hole to fill the space. Finally, the inserter was pressed over the graft until it snapped into place, and the graft was fully seated using the final impactor (Fig. 2H). The procedure concluded with the fluoroscopic verification of proper graft placement.

Lateral Approach

For the lateral approach, which used the Zavation SI Screw System (Zavation), patients were positioned prone on a radiolucent operating table under monitored anesthesia care with a C-arm fluoroscopy unit providing intermittent anteroposterior (AP), lateral, inlet, and outlet views throughout the procedure. Fig. 3 shows graphical illustrations of SIJ fusion using the lateral approach technique employed in this study. The procedure begins by inserting a spike to create an initial path for the instrumentation (Fig. 3A). A dilator was then introduced and advanced to the appropriate depth (Fig. 3B). Next, the inserter guide was tapped into place to ensure its teeth engaged the bone securely (Fig. 3C). After removing the dilator, the inserter guide was further seated into the bone by tapping the guide set, providing a stable working pathway (Fig. 3D). A pilot hole was drilled to the required depth under fluoroscopic guidance, with the inserter guide handle stabilizing the drill (Fig. 3E). Based on the drill depth, the appropriate SI screw was hand-tightened onto the inserter sleeve and gradually advanced into the predrilled pilot hole (Fig. 3F). Once the screw was properly engaged in the bone, the spike was removed, and the screw was fully seated, transfixing the ilium to the sacrum under fluoroscopic guidance to ensure precise placement (Fig. 3G, outlet view). Before the insertion of the screw, an autologous bone graft was packed into the screw cavity using an allograft packer to promote bone fusion (Fig. 3H, inlet view). If additional screws were necessary, an offset guide was used to mark the next screw location, and the process was repeated for optimal stabilization of the SIJ.

Postoperative Care

Following both procedures, patients were monitored closely for any complications and provided with detailed postoperative care instructions. No new neurological deficits were observed in any of the patients, and they were discharged once stable. Follow-up visits were planned to monitor pain relief and functional improvement. Both approaches were intended to provide lasting joint stabilization, pain reduction, and improved quality of life for patients with SIJ dysfunction.

Results

Baseline Demographic and Clinical Variables of Patients

Out of 135 medical records reviewed, 115 patients

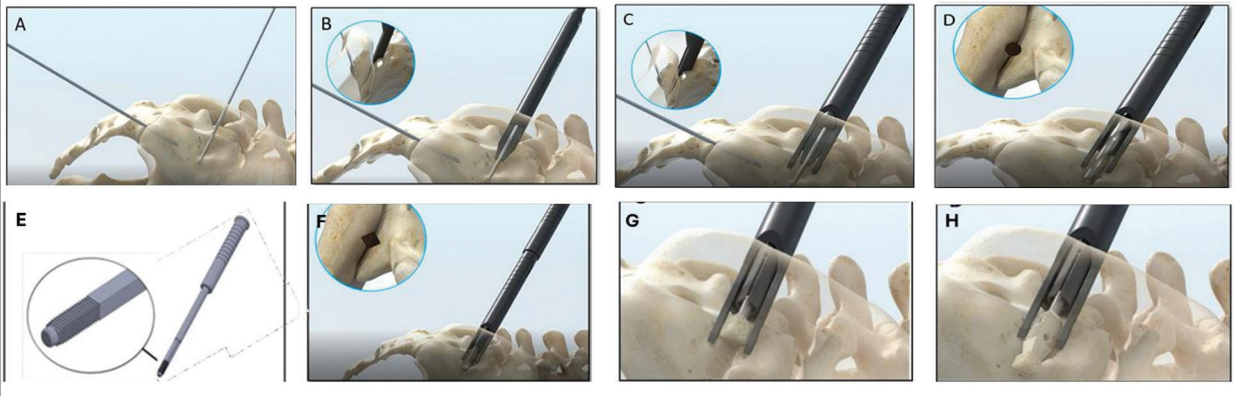

Fig. 2. *Graphical illustrations showing SIJ fusion using the posterior approach technique. A) Orthogonal placement of Steinmann pins at intersecting planes of 70-90° to each other in the anterior-posterior plane. B) The finder is placed over the pin and advanced until the shorter top shelf side bottoms out on the sacrum. C) The guide retraction tool is placed over the finder and gently impacted into the joint space until the short side contacts the sacrum. D) After removal of the finder and Steinmann pin, the drill is slowly advanced until the safety stop contacts the top of the retraction guide tube. E) The square broach with a round pilot is inserted into the retraction guide tube. F) The retraction guide tube with the square broach results in a diamond-shaped graft hole (inset). G) The demineralized bone matrix sponge (9 mm³) is positioned into the end of the inserter within the retraction guide tube and inserted into the graft hole with the final impactor. H) The graft is gently inserted into the graft hole using the final impactor.*
Source: Images adapted from CornerLoc Surgical Technique Guide with permission.

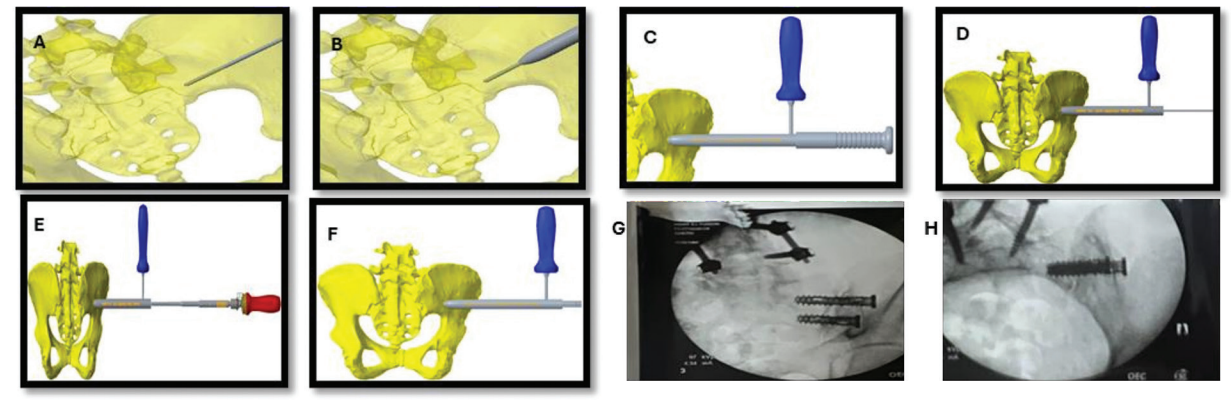

Fig. 3. *Graphical illustrations showing SIJ fusion using the lateral approach technique. A) A spike is inserted to create an initial path for the instrumentation. B) A dilator is introduced and advanced to the appropriate depth. C) The inserter guide is tapped into place to ensure its teeth engage the bone securely. D) The inserter guide is further seated into the bone by tapping the guide set. E) A pilot hole is drilled to the required depth, with the inserter guide handle stabilizing the drill. F) The SI screw is hand-tightened onto the inserter sleeve and gradually advanced into the predrilled pilot hole. G) An outlet view showing the screw seated transfixing the ilium to the sacrum under fluoroscopic guidance. H) An inlet view showing that an autologous bone graft was packed into the screw cavity using an allograft packer to enhance bone fusion.*
Source: Images A to F adapted from Zavation Surgical Technique Guide with permission; images G and H are original photographs.

met the inclusion criteria and were included in the final analysis. Table 1 presents the pre-procedure data on baseline demographic and clinical variables for all patients, with a detailed comparison between the posterior- and lateral-approach groups. Of these, 59 patients (51.3%) underwent SIJ fusion via the posterior approach, while 56 patients (48.7%) received the lateral approach. The average age of the cohort was 70 years (range: 40-93 years), and the majority of the patients were female (79 patients, 68.7%). The mean body mass index (BMI) was 31.3 ± 6.9, with 63 patients (54.8%) classified as obese at the time of surgery. Twen-

Table 1. *Baseline demographic and clinical variables of patients by surgical approach.*

Variables	All Patients (n = 115)	Posterior Approach (n = 59)	Lateral Approach (n = 56)	*P*-value
Age (years)	68.4 ± 10.6	69.0 ± 9.5	67.8 ± 11.7	0.268
Gender				
Female	79 (68.7%)	38 (64.4%)	41 (73.2%)	0.309
Male	36 (31.3%)	21 (35.6%)	15 (26.8%)	
BMI	31.3 ± 6.9	31.7 ± 6.9	30.9 ± 6.9	0.269
Normal	21 (18.3%)	10 (16.9%)	11 (19.6%)	0.868
Overweight	31 (27.0%)	17 (28.8%)	14 (25.0%)	
Class 1 obesity	30 (26.1%)	15 (25.4%)	15 (26.8%)	
Class 2 obesity	22 (19.1%)	10 (16.9%)	12 (21.4%)	
Class 3 obesity (severe obesity)	11 (9.6%)	7 (11.9%)	4 (7.1%)	
Employment Status				
Full-time	18 (15.7%)	6 (10.2%)	12 (21.4%)	0.313
Part-time	4 (3.5%)	3 (5.1%)	1 (1.8%)	
Unemployed/ Retired	45 (39.1%)	25 (42.4%)	20 (35.7%)	
Disabled	48 (41.7%)	25 (42.4%)	23 (41.1%)	
Tobacco Use History				
Current smoker	20 (17.4%)	10 (16.9%)	10 (17.9%)	0.740
Previous smoker	24 (20.9%)	14 (23.7%)	10 (17.9%)	
Non-smoker	71 (61.7%)	35 (59.3%)	36 (64.3%)	
History of Drug Use	22 (19.1%)	12 (20.3%)	10 (17.9%)	0.735
History of Lumbar Surgery	85 (73.9%)	42 (71.2%)	43 (76.8%)	0.494
History of FBSS	76 (66.1%)	39 (66.1%)	37 (66.1%)	0.997
History of SCS	63 (54.8%)	31 (52.5%)	32 (57.1%)	0.620
Duration of Symptoms				
6 months to one year	11 (9.6%)	5 (8.5%)	6 (10.7%)	0.394
One to 2 years	20 (17.4%)	13 (22.0%)	7 (12.5%)	
More than 2 years	84 (73.0%)	41 (69.5%)	43 (76.8%)	
Primary Joint Side				
Right	61 (53.0%)	29 (49.2%)	32 (57.1%)	0.391
Left	54 (47.0%)	30 (50.8%)	24 (42.9%)	
Proceed with the Other Joint Side	31 (27.0%)	16 (27.1%)	15 (26.8%)	0.968
Admitted Sleep Disturbances at Baseline	111 (96.5%)	58 (98.3%)	53 (94.6%)	0.284
Using Opioids at Baseline	78 (67.8%)	38 (64.4%)	40 (71.4%)	0.420
VAS – Baseline	8.7 ± 1.1	8.8 ± 1.0	8.7 ± 1.2	0.262
ODI – Baseline	45.2 ± 15.0	46.1 ± 13.5	44.3 ± 16.5	0.259

Abbreviations: BMI: body mass index; FBSS: failed back surgery syndrome; SCS: spinal cord stimulation; VAS: visual analog scale; ODI: Oswestry Disability Index.

ty patients (17.4%) had discontinued smoking 6 weeks prior to surgery, and 22 patients (19.1%) reported a history of drug use, including marijuana, without current consumption. At the time of surgery, a significant portion of the cohort (85 patients, 73.9%) had a history of prior back surgery, 76 patients (66.1%) had failed back surgery syndrome (FBSS), and 63 patients (54.8%) were using spinal cord stimulators (SCS). Additionally, 84 patients (73.0%) had experienced SIJ-related pain for at least 2 years. Baseline demographic characteristics showed no significant differences between the posterior- and lateral-approach groups (Table 1).

Before surgery, 111 patients (96.5%) reported sleep disturbances, and 78 patients (67.8%) were using opioids, with no significant differences between the posterior and lateral approach groups. The overall pre-SIJ fusion score on the VAS averaged 8.7 ± 1.1, while the score on the ODI was 45.2 ± 15.0. The average percentage of pain relief after the diagnostic injection was 78.3 ± 11.9%. Comparative analysis showed no significant difference in baseline VAS scores between the posterior (8.8 ± 1.0) and lateral (8.7 ± 1.2) groups (P = 0.262). Similarly, no significant differences were observed in ODI scores between the posterior (46.1 ± 13.5) and lateral (44.3 ± 16.5) groups (P = 0.259). Patients who presented with bilateral SIJ pain underwent sequential fusion, with the more symptomatic side treated first. A total of 31 patients (27.0%) in this cohort experienced satisfactory relief from SIJ fusion and decided to obtain contralateral SIJ fusion using a similar approach (Table 1).

Postoperative Outcomes

The average follow-up duration after the procedure was 11.3 ± 5.8 months, with a range of 3 to 24 months. Table 2 provides a comparison of post-procedure follow-up outcomes and patient-reported improvements based on the surgical approach. At the last known follow-up, the mean VAS score for SIJ pain had decreased by 59.9 ± 31.9%. Similarly, the ODI showed a significant improvement of 37.7 ± 27.5%. In addition to these improvements in pain and disability, there was a notable decline in pain-related sleep disturbances. Prior to the minimally invasive surgery, 111 patients (96.5%) reported sleep disturbances; however, this number decreased to 32 patients (27.8%) at the last known follow-up after surgery. The use of opioids also declined significantly, with 78 patients (67.8%) using opioids preoperatively compared to 51 patients (44.3%) postoperatively. Notably, 91 patients (79.1%) maintained their improvement at the last follow-up (Table 2).

Comparative analysis revealed significant differences in the outcomes between the 2 surgical approaches. The lateral approach demonstrated a significantly higher percentage of pain improvement on the VAS scale (66.3 ± 28.1% vs. 53.8 ± 34.2%, P = 0.017), greater functional improvement on the ODI (45.0 ± 25.5% vs. 30.7 ± 27.8%, P = 0.002), and higher rates of patients denying sleep disturbances (83.9% vs. 61.0%, P = 0.006), as well as lower recurrence rates (12.5% vs. 28.8%, P = 0.031) (Table 2).

To assess procedure durability, we conducted a Kaplan-Meier analysis. Fig. 4 illustrates the Kaplan-Meier curve, highlighting procedure durability (in months), with the posterior-approach group represented in blue and the lateral-approach group represented in green. The results showed that the average duration of pain relief and functional improvement, without requiring additional interventions or surgeries, at the last known follow-up for all patients was 18.9 months (95% CI, 17.2 to 20.6). Comparison of procedure durability using the log-rank test revealed a significant difference in favor of patients who underwent SIJ fusion via the lateral approach, with an average duration of 21.2 months (95% CI, 19.4 to 23.1), compared to 16.2 months (95% CI, 14.0 to 18.4) in the posterior approach group (P = 0.009) (Fig. 4, Supplementary File). Additionally, a Cox proportional hazards analysis indicated that the surgical approach affected procedure durability significantly (P < 0.05) (Supplementary File). The estimated risk ratio suggested that patients who underwent SIJ fusion via

Table 2. *Comparison of post-procedure follow-up outcomes and patient-reported improvements based on surgical approach.*

Variables	All patients (n = 115)	Posterior Approach (n = 59)	Lateral Approach (n = 56)	*P*-value
Length of Follow-Up (Months)	11.3 ± 5.8	10.6 ± 6.0	12.0 ± 5.6	0.104
Outcomes at Last Known Follow-Up:				
Denied Sleep Disturbance	83 (72.2%)	36 (61.0%)	47 (83.9%)	0.006
Using Opioids	51 (44.3%)	28 (47.5%)	23 (41.1%)	0.491
Improvement in VAS (%)	59.9 ± 31.9	53.8 ± 34.2	66.3 ± 28.1	0.017
Improvement in ODI (%)	37.7 ± 27.5	30.7 ± 27.8	45.0 ± 25.5	0.002
Condition Recurrence	24 (20.9%)	17 (28.8%)	7 (12.5%)	0.031
Procedure Durability (Months)	10.2 ± 5.8	8.7 ± 5.7	11.8 ± 5.5	0.002

Abbreviations: VAS: visual analog scale; ODI: Oswestry Disability Index.

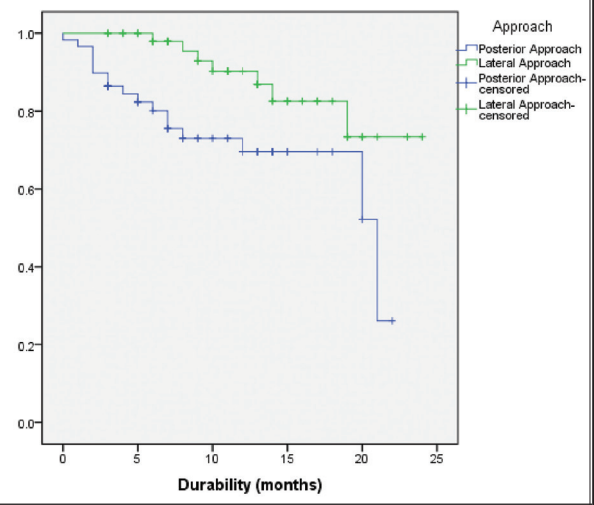

Fig. 4. *Kaplan-Meier curve illustrating procedure durability (in months), comparing the posterior-approach group (blue) and the lateral-approach group (green).*

the lateral approach had a lower risk of recurrence than did those treated with the posterior approach (risk ratio = 0.3; 95% CI: 0.1 to 0.8) (Supplementary File). Both the log-rank test and Cox proportional hazards model assume that the hazard ratio remains constant over time.

Safety and Complications

No new neurological deficits were observed in any of the patients. Out of the 135 medical records reviewed, 2 patients (1.5%) had their compression screws removed after the procedure. One patient experienced hardware pseudarthrosis with partial anterior placement in the soft tissue, leading to the extraction of the compression screw 2 months later due to a lack of transfixation of the joint. The second patient had persistent pain and intolerance to the compression screw hardware, requesting removal 2 months after the procedure. Additionally, 3 patients (2.2%) did not complete the 3-month post-surgery follow-up assessment. Those 5 patients were excluded from the final analysis due to not meeting the minimum 3-month follow-up period. No infections were reported in either group.

Discussion

Chronic SIJ pain remains a significant issue due to its high prevalence and burden on both society and the health care system. Notably, 66.1% of the patients in this study had FBSS, emphasizing the critical association between FBSS and SIJ pathology. Previous studies have reported that SIJ dysfunction is present in up to 30% of FBSS cases (30) and can be the primary source of LBP in as many as 63% of these patients (31). While SIJ fusion has become an established treatment, providing benefits in the forms of pain relief and quality-of-life improvements, the evidence on long-term clinical and fusion outcomes is still limited. Furthermore, no consensus exists on the optimal approach for SIJ fusion. Minimally invasive (MI) SIJ fusion has been associated with clinically significant improvements in pain and disability for the majority of patients across several studies and implant manufacturers (21).

The primary objective of this study was to assess the outcomes of MI SIJ fusion. In our retrospective cohort, patients who underwent MI SIJ fusion after not responding to conservative treatments showed notable improvements, with a 37.7 ± 27.5% improvement in ODI scores and a 59.9 ± 31.9% reduction in pain scores at the last known follow-up. These results are consistent with those seen by Rainov et al (32), who reported similar findings in a study of 160 patients who underwent lateral SIJ fusion, showing a pain reduction from 8.0 to 2.5 on the VAS scale ($P < 0.0001$) and an ODI improvement from 45.3 to 16.4 ($P < 0.001$).A prior study also noted that all patient-reported outcomes exhibited both clinically and statistically significant improvements at 12 months ($P<0.001$ for each): VAS scores improved by 6.6 points, and ODI scores decreased by 37.5 points (33). In the present study, the improvement in ODI met the minimum clinically important difference (MCID) thresholds, and the reduction in VAS pain scores exceeded reported MCID values for LBP (34-38). A significant finding in this study was the substantial decline in sleep disturbances related to pain, which dropped from 96.5% preoperatively to 27.8% at the last known follow-up. Chronic LBP is frequently associated with poor sleep quality, longer time to fall asleep, and reduced daytime functioning (39). Rapid improvements in sleep seen as early as 6 weeks after lumbar spine surgery have been documented in other studies, which have also found that surgically treated patients achieve greater improvements in sleep quality than do patients managed conservatively (40).

Our study also observed a considerable reduction in opioid use postoperatively. Before surgery, 67.8% of patients were using opioids, while only 44.3% continued using them after the procedure. This finding is consistent with those of other prospective trials, which have shown that more than half of patients who used opioids before surgery discontinued their use at the

6-month follow-up (41). In contrast, other clinical studies reported that 48-55% of patients continued using opioids 24 months after MI SIJ fusion (19,42). At the last known follow-up, 79.1% of patients maintained their clinical improvements, while the recurrence rate was 20.9%. A prior 5-year follow-up study demonstrated a high rate of joint fusion (88%) with excellent clinical outcomes in patients treated with triangular SIJ implants (14). However, recurrence and return to pain can occur and sometimes require revision surgery, a possibility potentially influenced by factors such as patient body type, activity levels, and comorbid conditions. In some cases, symptomatic pseudoarthrosis after SIJ fixation can be treated successfully with revision surgery involving decortication, grafting, and re-fixation with threaded implants. Implant trajectory is another factor contributing to the need for revision following MI SIJ fusion (43). In this study, any patient who did not maintain clinical improvement or who experienced a decline in their VAS or ODI scores was considered to have a recurrence. This factor may explain the higher recurrence rate observed in our study compared to those in other reports (44). A multicenter retrospective analysis of a novel posterior SIJ fusion device reported results similar to ours, with 22% of patients reporting less than 50% pain relief at their most recent follow-up and 10% experiencing no relief after 12 months, indicating a potential failure rate of 10% and a success rate of around 78% (45).

Our secondary objective was to compare the lateral and posterior approaches in the areas of pain relief, functional improvement, and procedure durability. Our study demonstrated significant differences between the 2 approaches. Martin et al reviewed the current evidence on MI SIJ fusion, assessing studies for both lateral and dorsal approaches (21). Regarding the lateral approach, a small number of studies describe the use of hollow modular anchor screws, while a larger number focus on triangular titanium implants (TTIs). Rappoport et al (46) reported that patients undergoing MI SIJ fusion with hydroxyapatite-coated screws using a lateral approach experienced significant improvements in leg and back pain, as well as ODI scores, at 12 months. A 2013 prospective case series of patients undergoing SIJ fusion using hollow modular anchorage screws concluded that the approach provided effective pain relief and functional improvement over a mean follow-up of 36 months (47). Similarly, a previous single-surgeon retrospective cohort study of lateral MI SIJ fusion reported significant improvements in all ODI subcategories (48). Many other studies on the lateral approach demonstrated comparable outcomes (49-51). As for the posterior approach, we observed limited published data on posterior SIJ fusion, which might have introduced an inherent bias favoring lateral SIJ fusion therapy. However, it is important to distinguish between a lack of available evidence and a lack of efficacy. A 2024 retrospective single-center study showed that 38.5% of patients experienced a 50% or greater improvement in pain, and 26.9% of patients experienced a 70% or greater improvement. These percentages mark the study as the largest single-center example to date involving posterior SIJ fusion (52). Another 2024 study, this one a single-arm, multicenter, prospective clinical study on the LinQ™ Implant System (Medtronic)—a minimally invasive posterior SIJ fusion allograft—suggested that the approach was a safe and effective treatment for SIJ dysfunction at 12 months, with results that were favorable compared to outcomes reported for an FDA-cleared lateral approach (53). Our study found that 61.0% of patients in the posterior-approach group denied sleep disturbances at the last known follow-up, a figure notably lower than the 83.9% reported in the lateral-approach group. Persistent sleep disturbances after spine surgery could be attributed to incomplete pain relief or a lack of overall improvement in quality of life (54).

At the last follow-up (11.3 ± 5.8 months after the procedure), the lateral-approach group maintained a significantly higher percentage of pain relief on the VAS scale, greater functional improvement on the ODI, lower recurrence rates, and longer procedural durability. Our Kaplan-Meier analysis also revealed a decline in improvement over time in the posterior-approach group. The lateral approach is often preferred due to its low revision rate and greater fusion stability. This may be because the lateral approach targets a smaller joint space with increased cortical bone volume and density, leading to better implant fixation across the joint. In contrast, posterior grafts may fail to fuse properly, if placed in the ligamentous portion of the joint or due to graft resorption or graft fracture (22,55). Radiographic evidence shows that the lateral transiliac approach achieves successful fusion in 85% of patients (56). A study comparing the newer MI posterior approach with the lateral method found that while both approaches provided similar stabilization during flexion-extension motions, the posterior approach offered better stabilization during lateral bending and axial rotation (57). Although the literature does not definitively favor one approach over the other, some studies contradict

our findings by supporting the observation that outcomes are superior when the posterior approach is used (58,59). Additionally, a retrospective study using Kaplan-Meier analysis has suggested that SIJ fixation with screws has a higher revision rate than SIJ fusion with bone-adherence implants, which contrasts with our analysis (60). However, this analysis did not compare the lateral and posterior approaches directly.

This study contributes to the growing body of evidence on MI SIJ fusion by providing a direct comparison of lateral and posterior approaches within a single-surgeon setting. Both approaches offer significant benefits; however, the findings suggest that the lateral approach used in our study has potential advantages over the posterior approach, particularly in achieving long-term pain relief, functional improvement, and lower recurrence rates. These outcomes align with existing studies supporting the efficacy of MI SIJ fusion techniques, while also emphasizing the need for more robust, multicenter studies. Unlike previous research, this study underscores the influence of surgical technique, implant selection, and surgeon expertise within a single-center setting on patient outcomes, offering valuable insights for optimizing SIJ fusion practices. Further research using diverse implant systems—particularly those with the most robust evidence for both approaches—is essential to validate these findings and guide clinicians toward evidence-based decision-making.

Study Limitations

This study has several limitations. Its retrospective design and the lack of randomization between the lateral and posterior approaches, combined with the exclusion of patients who did not complete the 3-month post-surgery follow-up, make it susceptible to selection bias. The reliance on patient-reported outcomes may also introduce inaccuracies. Additionally, being conducted at a single center under the expertise of a single surgeon limits the generalizability of the findings. Furthermore, the study evaluates only one posterior fusion system, making it inappropriate to generalize the results to all posterior SIJ fusion techniques. Many patients included in the study had comorbidities that might have contributed to lower back pain, acting as confounding factors in assessing pain relief from the SIJ fusion. Larger, multicenter prospective studies with standardized protocols are needed to validate these findings and provide a more comprehensive comparison between surgical approaches.

Conclusion

This study highlights the clinical effectiveness of MI SIJ fusion in improving pain and functional outcomes for patients with chronic SIJ dysfunction unresponsive to conservative treatment. Both lateral and posterior approaches offer significant benefits, but our findings suggest that superior outcomes may potentially occur with the lateral approach, particularly in the areas of long-term pain relief, functional improvement, and lower recurrence rates. In contrast, the posterior-approach group showed a decline in improvement over time. These findings should not be generalized to all posterior SIJ fusion techniques, since our study evaluates a specific device rather than the broad spectrum of available posterior fusion systems. Further validation through prospective, multicenter studies comparing well-established posterior and lateral fusion devices are needed to guide clinicians in determining the most effective surgical approach for SIJ fusion. Ultimately, while SIJ fusion is a valuable option for managing chronic SIJ pain, personalized treatment plans based on patient characteristics and comorbidities remain critical to optimizing outcomes.

Ethical Approval and Consent to Participate

This study was conducted in accordance with the Ethical Principles for Medical Research Involving Human Subjects as outlined in the World Medical Association's Declaration of Helsinki, revised in 2013. All patient data collected were de-identified to ensure confidentiality. An IRB waiver was granted by BeyondBound IRB (IRB ID#: BB2408MN-015) on August 3, 2024. Because the study involved a retrospective review of de-identified data, a waiver of informed consent was requested and granted by BeyondBound IRB in accordance with the applicable exemption criteria.

Author Contribution

Dr. Gheith, who had full access to all the data in the study and performed all surgeries, takes responsibility for the integrity of the data and the accuracy of the data analysis. Wortmann, AGNP-C, participated in data collection and study design and contributed to manuscript preparation. Dr. Najjar wrote the study protocol, performed the statistical analysis, managed the literature review, and wrote the first draft of the manuscript. Dr. Gheith and Wortmann, AGNP-C, provided revisions for intellectual content and the final approval of the manuscript. All authors reviewed and approved the final version.

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Conflicts of Interest

Dr. Gheith and Wortmann, AGNP-C, disclose that they serve as faculty lecturers for Zavation and receive compensation for this role outside the scope of the submitted work. The authors declare no other conflicts of interest related to this study. None of the authors received any remuneration beyond their regular salaries. Furthermore, the authors have not received any reimbursement or honorarium in any other manner. However, all the authors are affiliated with the Interventional Pain Institute: Dr. Gheith practices as an interventional pain physician, Wortmann, AGNP-C, as a pain management nurse practitioner, and Dr. Najjar as a clinical research coordinator

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Supplemental Table 1. *Log Rank test table.*

Approach	Mean			
	Estimate	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Posterior Approach	16.2	1.1	14.0	18.4
Lateral Approach	21.2	0.9	19.4	23.1
Overall	18.9	0.9	17.2	20.6

Overall Comparisons			
	Chi-Square	df	Sig.
Log Rank (Mantel-Cox)	6.8	1	0.009

Test of equality of survival distributions for the different levels of approach.

Supplemental Table 2. *Cox's proportional hazards analysis.*

Omnibus Tests of Model Coefficients[a]						
-2 Log Likelihood	Overall (Score)			Surgical Approach Effect on the Model		
	Chi-square	df	Sig.	Chi-square	df	Sig.
190.699	6.726	1	0.010	6.790	1	0.009

	Sig.	Risk Ratio	95.0% CI for Exp (B)	
			Lower	Upper
Lateral Approach	0.014	0.329	0.136	0.795